

fsPHENIX Heavy-Ion Observables: 3-D Event Shapes

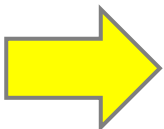
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sPHENIX Cold QCD PWG

8 May 2017

Forward interest in QGP physics

- Characterizing medium at non-central rapidity
 - Is QGP formed at rest in high-rapidity frame? If not, why not? since conditions largely the same as mid-rapidity
 - QGP signatures: look for flow/hydro behavior, jet-medium interaction, (possibly) thermal photons
 - See QGP variation with baryon density
- Long-rapidity correlations are imprinted at early times in any local evolution picture, e.g. hydro
 - Access/diagnose initial energy deposit and/or thermalization mechanisms, e.g. pre-QGP
 - Forward-mid correlations, many approaches
 - Look at full 3-D event shapes



fsPHENIX selling point

Q: What does fsPHENIX offer, that is not already being done by ATLAS/CMS, ALICE or STAR?

A: Uniform, low-threshold calorimetry to $\eta \sim 4$

Look at the whole event at once! Suggested measurement:

- Look at $d^2E_T/d\phi d\eta$ on each event
- Take 2-D Fourier transform
- Square, average, look at power spectrum
- (Very analogous to astro/cosmology, e.g. CMB)

Not original with us...

Spherical Harmonic Decomposition

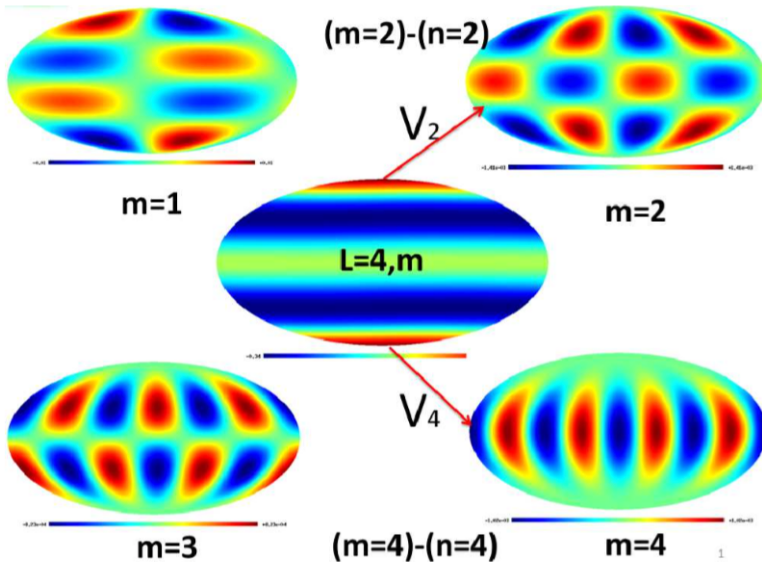


FIG. 5: (Color online) Schematic representation of the contribution of v_2 (elliptic) and v_4 flow to the various m components of the $b_{l=4,m}$ -coefficient. The v_2 -modulation will change the amplitude and the phase of the $b_{4,2}$ coefficient without contributing to the other components. The v_4 modulation will only change the $b_{4,4}$ component.

Morphology of High-Multiplicity Events in Heavy Ion Collisions

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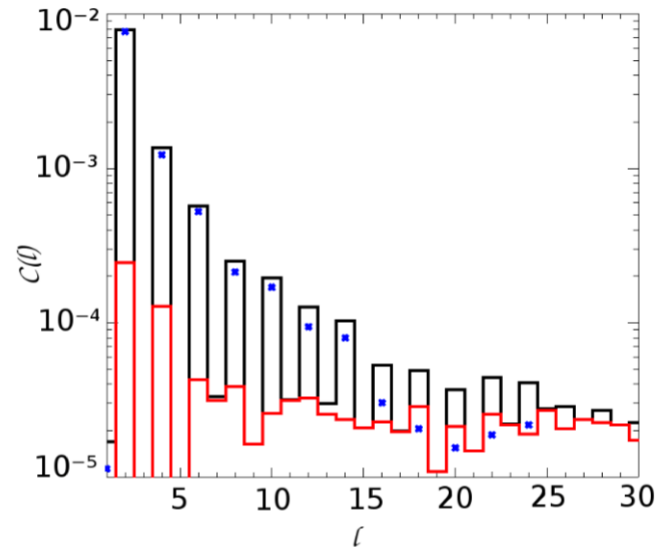


FIG. 6: (Color online) The power spectrum for an event with elliptic flow $v_2 = 0.07$. The total power $C^S(l)$ is shown in black, the blue stars correspond to $C^S(l) - D(l) = C(l)$, and the $D(l)$ power spectrum is shown in red (see Eq.(3)).

Phys. Rev. C 86,
024916 (2012)

[http://arxiv.org/
abs/1204.0387](http://arxiv.org/abs/1204.0387)

Getting down to concrete

$$E_T(\phi, \eta) = E(\phi, \eta) \times \sin(\theta)$$

$$f(n, k) = \int_{-1}^4 \int_0^{2\pi} E_T(\phi, \eta) e^{-i(n\phi + \frac{2\pi}{\Delta\eta} k\eta)} d\phi d\eta$$

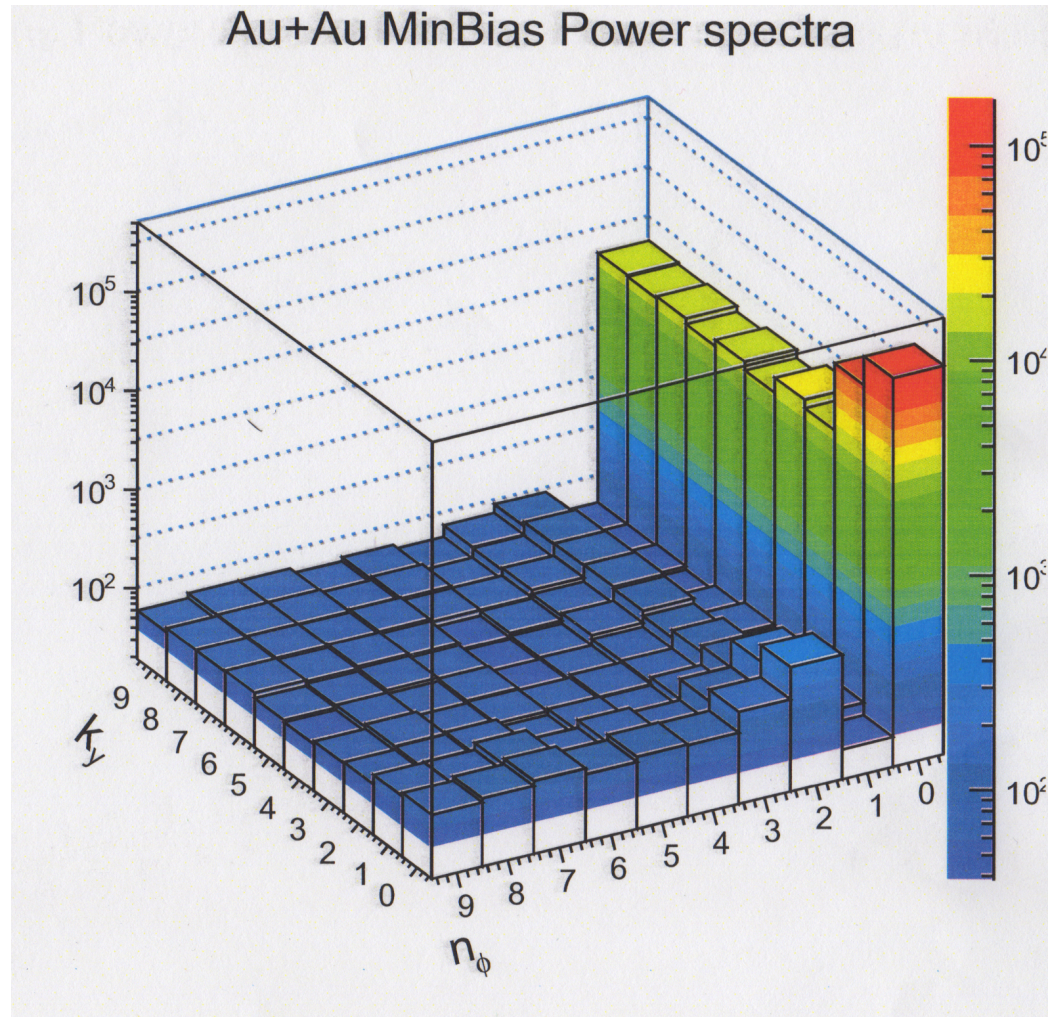
$$P(n, k) = |f(n, k)|^2$$

n = azimuthal ϕ index

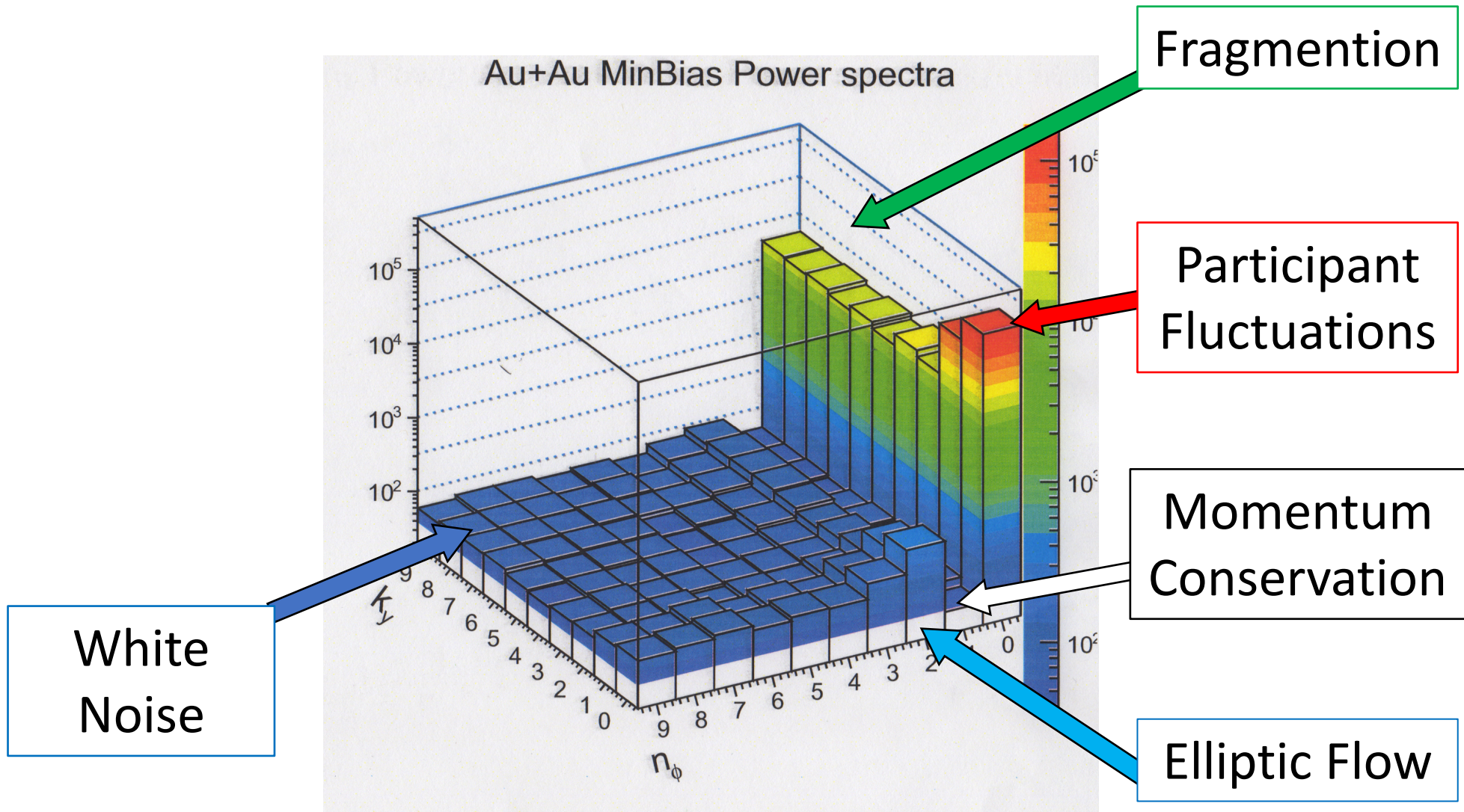
k = longitudinal η wavenumber

NB: According to the Wiener-Khinchin Theorem, the Fourier power spectrum $|F(\omega)|^2$ contains the same information as the 2-point correlation function $\xi(\Delta t)$

First look, from AMPT events



One-stop shopping



Pros and cons

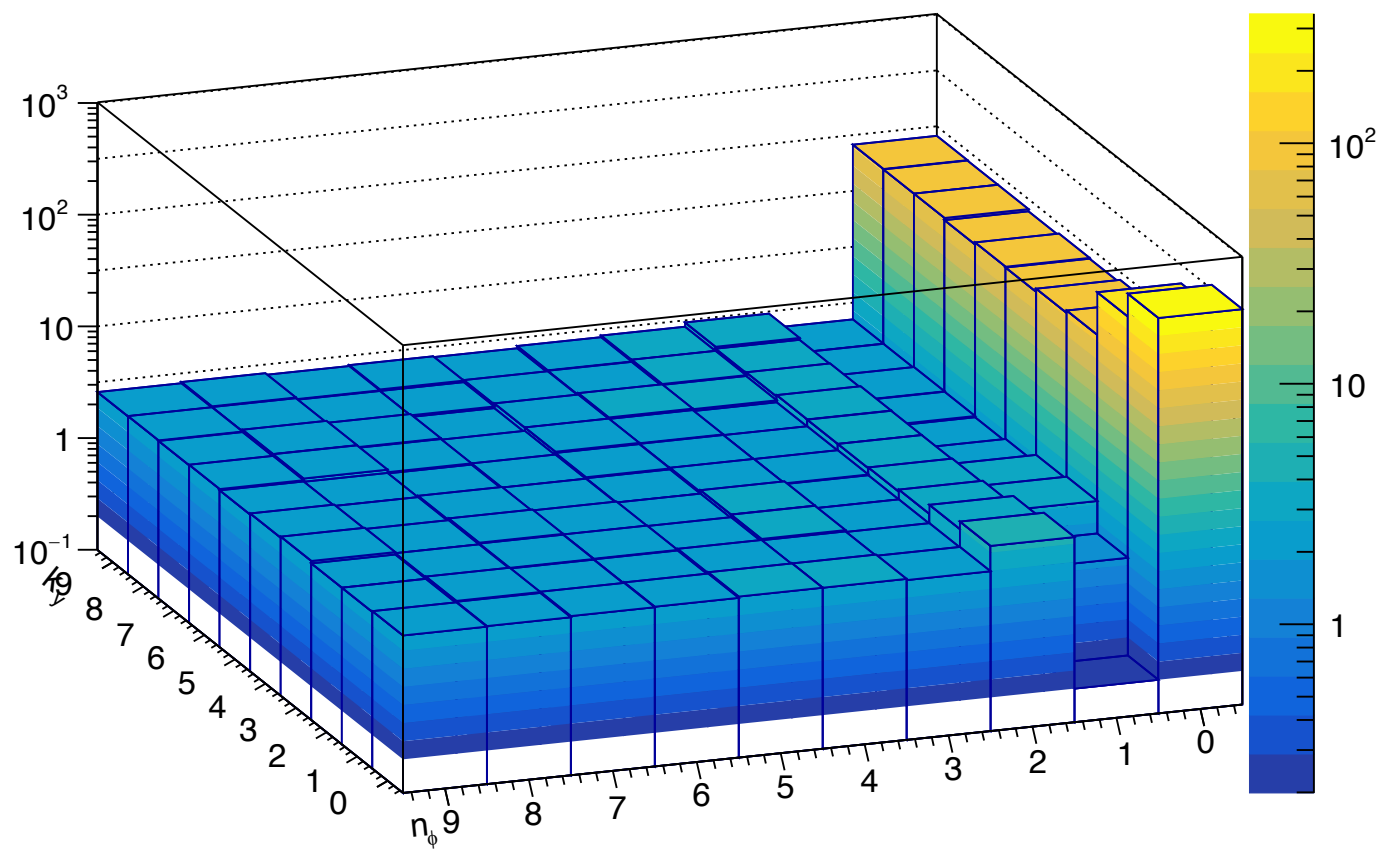
- Full event shapes have all the correlation information, simultaneously
- Very well-defined, very good meeting ground for theory and experiment
- Ecumenical: no dependence on methods or assumptions, e.g. non-flow subtraction, etc.
- Highlights fsPHENIX world-unique capability
- Not a familiar observable, will take some time to learn how to look at it
- No “concrete” connection to initial-state physics yet

State of Play

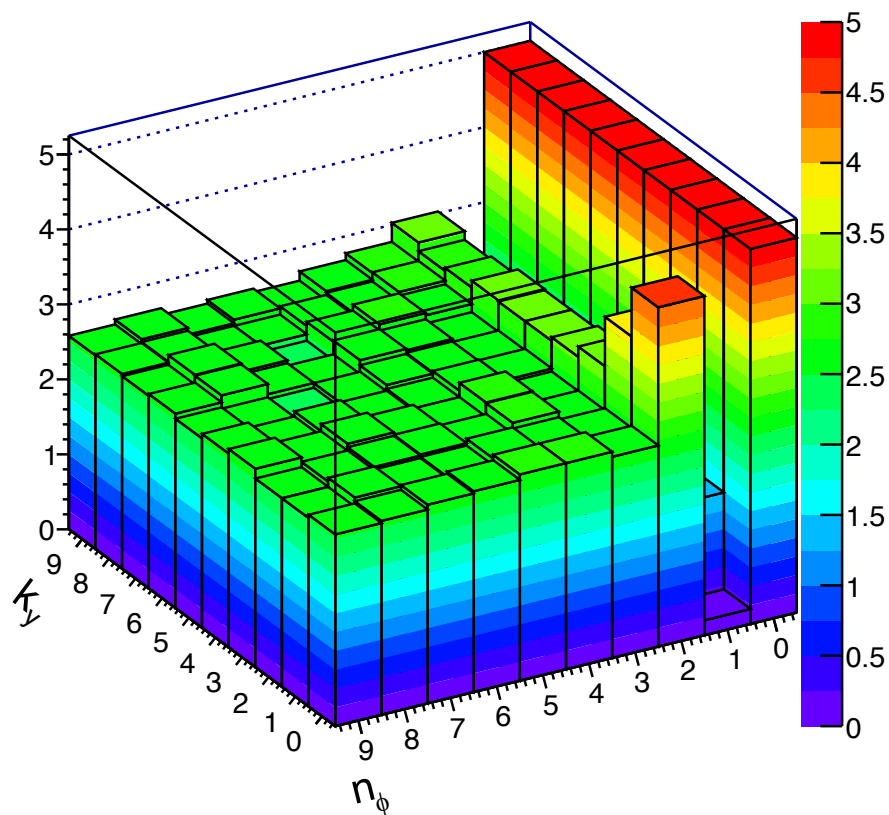
- We could include mention of this approach in the fsPHENIX LOI, that would arguably advance the state of QGP/Heavy-Ion physics; illustrated by results from event generator simulation.
- So far no realistic detector effects modelled, but reason to think the measurement would be very tractable in fsPHENIX.
- Currently in discussion with some theoreticians, may be able to get cartoon-level descriptions of what to expect for different initial-state pictures.

Backup

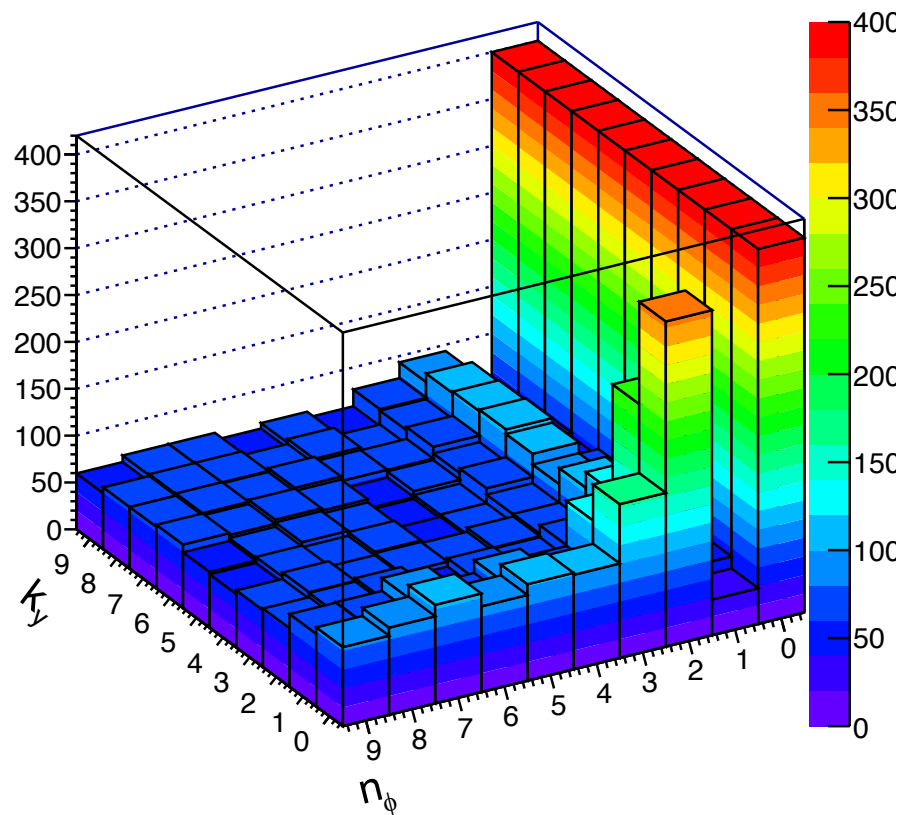
d+Au MinBias



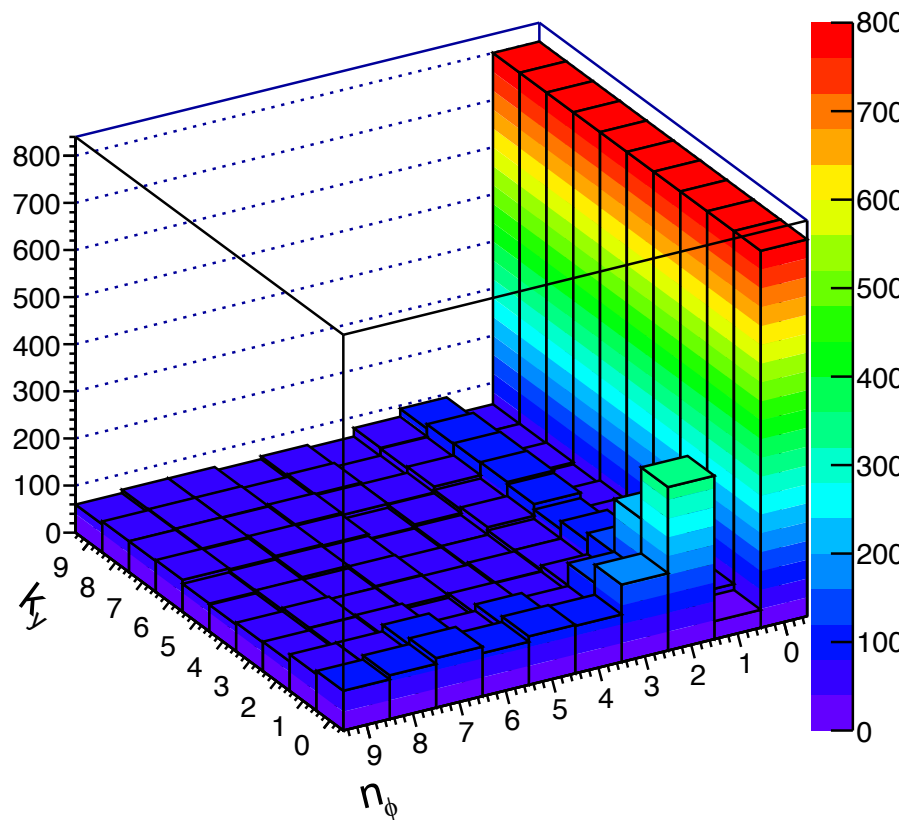
d+Au MinBias Power spectra (2000 evts)



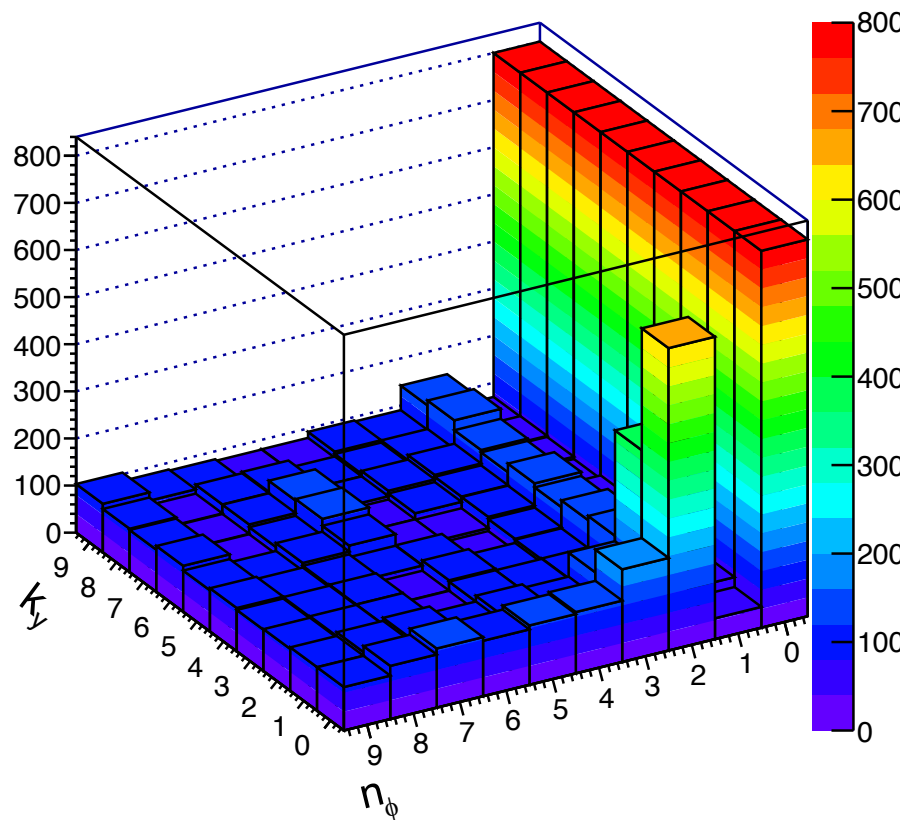
Au+Au MinBias Power spectra (2000 evts)



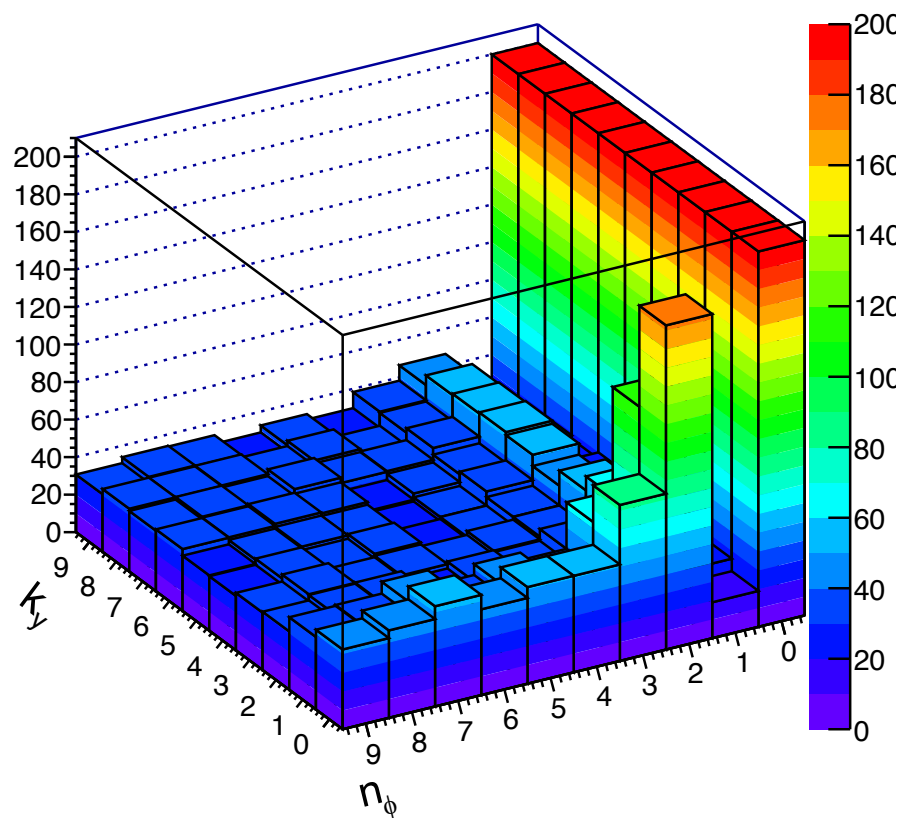
Au+Au MinBias Power spectra (2000 evts)



Au+Au 20-40% Power spectra (2000 evts)



Au+Au MinBias Power spectra (first 1000 evts)



Au+Au MinBias Power spectra (next 1000 evts)

